

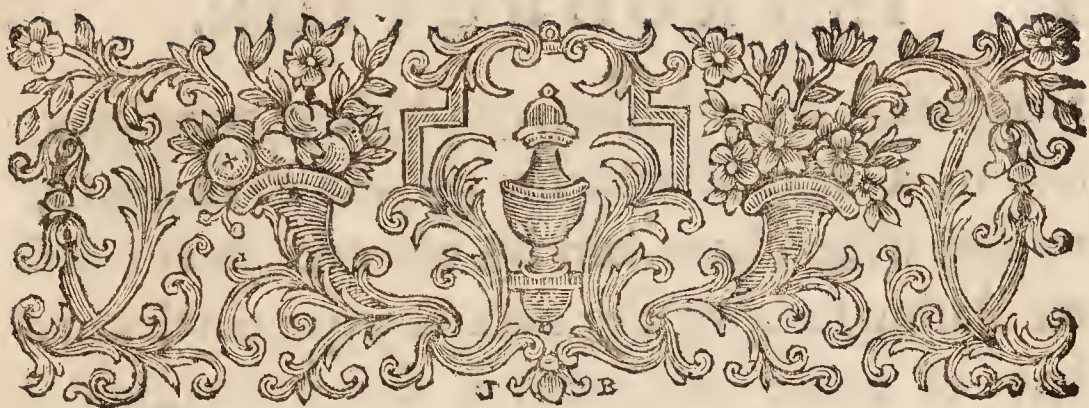
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THE
PRINCIPLES
OF
Natural Philosophy:
WITH SOME
REMARKS
UPON THE
FUNDAMENTAL PRINCIPLES
OF THE
Newtonian Philosophy;
IN AN
Introductory *LETTER*
TO
Sir HILDEBRAND JACOB, Bart.

L O N D O N:

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T O

Sir HILDEBRAND JACOB, Bar^t.

S I R,



S you, with some other of my friends, did me the honour to publish the first Part of the following short *Essays*, in the year 1748 ; I thought myself bound in gratitude to address them to you, now they make their appearance in public together. My studies, for some years before, having a considerable connexion with natural philosophy, I had at leisure hours drawn up the first Part, without any intention of making it public: but it happening to please you and some friends, whose judgement I trusted to more than my own, it was printed. From that time I began to consider it as a regular

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foundation for a System of physical principles ; and in a year after drew up *the Principles of motion*, which have lain by me ever since. After stating some of the necessary properties and laws of matter and motion, the prosecution of the plan would require, in the same manner, to collect separately the distinguishing properties of the different species of matter comprehended in the System of nature, so far as experience and reason can instruct us ; and then to shew how they are mechanically adapted to co-operate in producing the beings and sensible modifications of matter in nature, particularly those appearances, which philosophers have reasoned upon as occult and unmechanical, and yet regular and inviolable.

It is somewhat astonishing, that the inquirers after physical truth should observe and acknowledge mechanism in any part of nature, and not be led to inquire, whether it is not universally extended ; especially as all matter and motion must have the same absolute invariable properties. If vapour rises mechanically, why may not a stone descend by the same law ? If fluids circulate in organiz'd
bodies

bodies by continued impulse, why not a planet revolve by the same cause?

It may appear odd to throw the blame of the false systems of philosophy, which have been lately invented, upon the abuse of a branch of science, which of all others is believed to give the fullest degree of evidence mankind is capable of receiving, namely, the Mathematics: and yet I suspect it is too true. Mathematical evidence is a phrase for the highest degree of certainty; and all other truths, the most important and interesting not excepted, must be received in the mind with a weaker and obscurer degree of persuasion, because their proof is supported by an inferior or more fallible demonstration. You are not ignorant, Sir, that this is the common boast of the mathematical philosophers in praise of that science. The inference is very obvious. In their mathematical reasoning it follows, That the Deity can give his creatures no such evidence for any truth he would have them receive, as they can attain of themselves by lines and figures: therefore they are not, they cannot be absolutely certain they are not imposed upon.

Mathematics are a science of great importance and use, and have it in their nature to be true, while apply'd to compare the relations of the figures of matter and motion: but the same reasoning carried beyond these, becomes subtil absurdity. I shall have occasion hereafter to mention a remarkable instance of this, in reasoning from the properties of a figure to the powers of motion; as they do, who pretend to explain the elliptical and parabolical motions of the planets and comets by the powers of centripetal force and projection.

A most remarkable abuse of this science presents itself in the very Definitions which Mathematics set out with. These are substituted for the elements of matter. A Point is that which hath no breadth, nor length, nor thickness; or which hath no extension. Now, Sir, can that, which hath no material properties, be the first principle of all material substances? Tho' you or I may think otherwise, I assure you, by two or three more such mathematical Definitions it can. A Line is a range of such points; a Surface is a range of such lines; and a Solid is a composition of such surfaces. Thus you see, Sir, as the ultimate judgement form'd
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upon mathematical evidence, defies the Creator's power to give any such demonstration of his own being or will ; so what is laid down as the first principles of Mathematics, abolishes his creation, to make room for one formed upon such elements.

I doubt not but many will reckon this a very strained and invidious inference. But if I had looked upon these Definitions only as unmeaning subtilties in the speculative part of Mathematics, I should not have given you the trouble of this remark. But, whatever may be pleaded to the contrary, it is self-evident, that these Definitions exactly coincide with, and are really the ground-work of our modern natural philosophy. Could any one persuade you, Sir, that the infinite divisibility of matter has no connexion with the above non-entity, a mathematical Point? And we all know, how necessary the doctrine of infinite divisibility is to the present system of philosophy. Have not the propagation of light, and many of the greatest *phenomena* in nature, been explained by it? and are we not obliged to it, for that glorious mathematical Idea, the rarefying a grain
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of sand 'til it swells to the magnitude of a planet, or fills infinite space?

It is no wonder, that these sublime mathematical Ideas should exalt the mind, beyond mathematical evidence, to all the pretended analogical conjectures, which these refined imaginations could devise, and which are received by many as the most undoubted truths—such as, The scale of beings, The systems of comets, The supply of the solar fire, The plurality of systems, The conjectures built upon the thirteen stars of the first magnitude, twenty-six of the second, &c. The galaxy, &c. &c. : with many other expedients for replenishing infinite space, establishing a *plenum* of motions and revolutions, but a *vacuum* of matter where these motions are described, lest they should be incumbered in their career. What is amazing in all this is, That, tho' the modern philosophical Creed be full of these uncertainties, yet many of the most unshaken believers of it are so cautious, as to suspend their assent to all divine truths, for want of mathematical demonstration.

I shall always account it my happiness, that I was not acquainted with the natural philosophy

phy of the Schools, before I heard of another which bid as fair for truth ; and that I had the privilege of making a choice, before I could be prejudiced in favour of any system. I am not ashamed at the same time to confess, that my education was such, as made me however wish, that the philosophy, which was asserted to be taught by Revelation, might be supported with evidence becoming the wisdom and authority that unfolded it. I now am convinced, and even flatter myself, am able to demonstrate that it is so.

The followers of the *Newtonian* system do well to affect a contempt of every thing that may be opposed to their *Hypothesis*. Doctrines, which are supported by popular reputation, save the partisans of such tenets a great deal of trouble and vexation, which might otherwise attend the discussion of knotty objections. I would choose neither to boast, nor insult ; but do think, that in all reason, they, who are not willing to give up that system, ought to undertake a fair defence of it.

Mathematics have no concern in the dispute. The controversy is reducible to one single point ;

point ; Is there a *vacuum*, or not ? Let them either produce their proof of it ; or disprove the arguments we shall bring for a *plenum*. A *vacuum* is the *postulatum* which supports their whole fabric. Sir ISAAC NEWTON has nowhere proved it ; yet it is evident, the three properties of matter, which are the Axioms or evident principles, in all his reasonings upon motion, cannot be granted, unless a *vacuum* is first ascertained.

His first Axiom is, That all bodies, once put in motion, have as constant a tendency to move, as they have to rest before motion is impressed on them. It is true, this law needs no proof but experience of the fact. But where made Sir ISAAC the experiment ? Not on this globe ; because the surface of it is so involved in air and light, that it was absolutely impossible for him to try a projection *in vacuo*. Not among the planets, nor in the spaces between them ; for he was never there, at least not before he compiled his system of philosophy. Besides we are pretty sensibly informed, that there is a continuation of luminous matter between us and all the orbs. But all the philosophers of that class hold that fluid to be so rare,

rare, as to be of no account in affecting the motion of bodies: tho' unhappily for them, they cannot demonstrate, that there is one of their mathematical points of space, which it does not occupy; their senses argue against them, and they themselves allow it a wonderful rapidity of motion.

Is it not strange then, Sir, that a Man should take upon him to determine and establish a law about the continuation of motion, without the continuation of the cause; never regarding an all-surrounding fluid, which necessarily must have some influence, both in promoting and overcoming all the motions he could ever make observation upon? To say nothing of the light, we are absolutely certain, the air resists motion; and by numberless experiments upon the air-pump, Sir ISAAC was, or might have been, as absolutely certain, that air promoted it. He knew with what power the air pressed upon his *vacuum*, and with what velocity it rushed into it: he knew also, that every moving body continually leaves a *vacuum* behind it, which the air must exert its power upon in the same manner. Nevertheless, he explains the *areas* which all projectiles describe,

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by the two laws of *vis inertiae* and gravitation alone. If it should be argued, that these two powers are only terms, which he used to include all the accidents that contribute to continue motion; then we say, whatever service he has done mathematics, he has hurt natural philosophy by his obscure and fallacious terms.

A *vacuum* is no less necessary for ascertaining his two other Axioms, than it is for the first. But the third not only depends upon his assumed *vacuum*, but is founded upon his great relative property of matter to matter, namely Gravitation. Can any thing be more inadvertent and delusive, than to assume That as an absolute law of matter, or primary Axiom, which is the consequence of a secondary law, or of the relation of one parcel of matter to another? His Axiom is, that re-action is equal to action, or that one body, put into motion by another, destroys just as much motion in the first as it receives from it. Let us reflect a little what is the cause of this fact, assumed as an Axiom. Why does every body resist the action of another upon it? It is its native power. How does this native power in bodies manifest

manifest itself? By their weight. What is the weight of a body? It is the force with which it is attracted towards the earth. So then this Axiom depends upon Gravitation, tho' it is assumed independent of it. But if it must be an Axiom, I would be curious to be informed, Whether a body would weigh or not (for resistance is most certainly the same with weight) if the power of Gravitation were not acting in it: and if it did, I would be still more curious to know, in what direction it would weigh.

Sir ISAAC has not even reduced his favorite principle of Gravitation to self-consistent laws. We are told, that this principle is of the same nature, and acts by the same laws, in all matter; that all attraction in bodies is mutual; that its power of action is in proportion to the quantity of matter contained in the bodies. But if that power of Gravitation be in every respect mutual between two bodies, then the degree of gravitation (which is known by the acceleration of the motion) must be in proportion to the quantity of matter in the smaller body, as well as that of the larger: that is, if the earth were left to the simple effect of

Gravitation or centripetal force, it would descend to the sun, with a velocity proportioned to the power of attraction in the sun and in the earth added together. Therefore a stone-weight of substance attracted by the sun, would move only with a velocity proportioned to the simple power of the sun's attraction, the stone weight's power being in proportion as nothing. But this is false in fact, for a feather gravitates as fast towards the earth, as a 1000 tons of the most solid substance. Now if the earth attracts according to its quantity of matter, why should not a mountain of the substance of the earth, and every particle of it endowed with the same law, gravitate according to its quantity of matter, and descend faster than a body which has not the 100,000 part of its substance?

If we reason upon this principle in the reverse light, from what is matter of fact, it appears equally absurd. If a small body gravitates as fast towards the earth as the largest does, then the quantity of matter makes no difference as to the power of Gravitation: but if a larger quantity of matter descending is not more strongly precipitated towards

towards the earth than a smaller ; then the greater or lesser quantity of matter contained in a planet cannot dispose it to attract bodies more or less powerfully. For if there is no difference of velocity between the descent of the smallest and the largest body, gravitating toward the earth, then there can be no difference between the attracting powers of a small body and the largest planet ; if it be still true, that this principle acts by the same laws in all matter. In short, Sir, there is a mystery of contradiction, obscurity, and confusion in this part of the *Newtonian* philosophy, which is smoothed over by a kind of mathematical legerdemain.

Another law of the centripetal power is, That it decreases reciprocally in a duplicate proportion of the distance. That is, a body, double the distance that it now is from the centre of the earth's gravity, would gravitate or weigh four times less ; at thrice the distance, nine times less. How easily may this law be traced into an absurdity. For example, we must suppose, that it increases and decreases in the same *Ratio* : but if it increases in the same *Ratio*, how will reciprocal duplicate proportion

tion increase to infinity, when these distances come to be divided by yards, inches, and hair-breadths from the centre? In a hair's-breadth itself from the centre, it will increase millions of times, by that kind of mathematical mensuration, which makes a hair's-breadth admit of infinite division.

What a jest is it then, SIR, for these gentlemen to pretend to calculate the densities of planets, the quantities of matter contained in them, or their special powers of attraction, by such laws! I know they will be very angry with us, for measuring the above law, by such divisions as their own refinements on Mathematics afford us; because they think we laugh, and don't do it with the same gravity that they tell us, how much a pound weight would weigh upon the surface of the Sun, or *Jupiter*. But I hope we may laugh sometimes with a serious meaning, as well as others be grave with a ridiculous one.

It is, in my opinion, a most necessary piece of true wisdom for us, to know where our finite capacities are bounded. Infinite wisdom has placed enough within the reach of our understanding ;

standing, which we ought to employ it upon. But we forsake that, and go in quest of imaginary worlds and systems not of GOD's making; and frame laws for ruling the world we do know, which laws cannot be of GOD's composing, as they infer the greatest absurdities. It would be just as modest for one of these philosophers, to inform us what matter, or their attraction is, as to calculate by their rules, how many feet the moon would gravitate towards the earth in a minute.

Sir ISAAC NEWTON's friends alledge, from some of his *Queries*, and some cautions scattered in his *Principles*, that he had even some idea of that occult power, its being performed by the impulses of a subtil fluid disseminated thro' his infinite space, tho' he was too modest to be dogmatical about it. But tho' he had sincerely meant so, it was only retiring a step farther into the dark; and he might as well have plainly confessed his unmechanical power of attraction, as have attributed it to another unmechanical agent. For we must ask, By what principle that subtil fluid acts? And the ultimate answer must be, The *vis inertiae* and a *vacuum*. I am not inclined to judge of that great
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man's secret reasons for wavering about his principle of Gravitation: but if, by assuming some hints from the mechanical philosophy, he designed to shew the world, that he even penetrated a little into the causes of these obscure powers, he has not in fact advanced his character by it; for his Axioms throw him back again into his unmechanical *dilemma*. But it is not easy to guess what he intended by these seeming doubts; for in other parts of his Works, where he may be supposed to speak his own sense more peremptorily, he establishes Gravitation as an universal property of all matter, his energetic fluid not excepted; and asserts it to be a principle, that acts not only by matter in *cumulo*, but essential to, and exerted by, every particle of it.

The greatness of Sir ISAAC NEWTON's character, and the palpable deficiency of former *Hypotheses*, have been a blind to his followers. His character as a mathematician, and not his demonstrations as a philosopher, have been the confirmation of his physical principles. Whoever has ventured to differ from him, however weighty their objections may have been, have only incurred the character of conceit, obstinacy,

obstinacy or ignorance. The foreign philosophers have suggested many objections and difficulties which deserved the attention of the *Newtonians*; but these took the benefit of the character of infallibility, which opinions acquire when they become popular; and have answered them not a word.

While *Sir Isaac*'s discoveries have been thus adored, what contrary treatment have the discoveries and characters of his cotemporary Mr. HUTCHINSON met with! tho' it may be submitted to NEWTON's most partial admirers, which of the two's doctrines (even supposing them equally just) are most important, and discover most of the natural philosopher. What is properly *Sir Isaac* NEWTON's in the present philosophy, is his extending Gravitation to all matter, and by a most profound skill in Mathematics, forming rules for calculating the decrease of that power, by the increase of the distances of the attracting bodies from one another.

Mr. HUTCHINSON has laid down principles, which may enable any person to discover, how Gravitation is mechanically performed.

ed. This was what the *Newtonians* had not the remotest idea of; nor did they conceive any thing about it, in such a manner as to give them any hopes of discovering the cause. He has discovered the certainty and the necessity of a *plenum*; a doctrine, which the *Newtonians* abhorred, as much as Nature (according to the school-men) abhorred a *vacuum*. He has shewn how the solar fire is supported, without the assistance of a dense atmosphere, comets, or any such expedients. He has explained what air is; and tho' he has not descended particularly to explain all the *phenomena* in nature, he has established such a material mechanism, as will account for all her operations, without having recourse to occult powers and unmeaning terms. All these were more than ever the philosophers expected to know.

Of this philosophy Mr. HUTCHINSON had two proofs. The one was to demonstrate it by experiments, and to reduce any necessary parts of it to geometrical proportions. As many of these had been made and calculated by preceding philosophers, who could never investigate the causes, he left these to be explained and applied, as a just idea of philosophy should direct :

rect: knowing that experiments particularly will always answer for themselves, and cannot be pressed into the service of false masters.

He therefore addresses himself to another proof, which was quite new, and which he carried on with a success suitable to the nobleness of the design; a proof, for which he ought to be held in incomparably greater honor, than if he had, by the sole dint of genius, produced the most refined and consistent *hypothesis* that human capacity could boast of: tho' perhaps it has gained him more enemies, than if he had been the most contemptible system-compiler, that ever pretended to be a philosopher. He proves, that we have in Revelation a discovery of the mechanism of Nature, given us by Him, whose knowledge of it must be infallible and indisputable, because He is the author and supporter of its being and structure.

Tho' you are before-hand with me, SIR, in all I can say on the subject, you will excuse my just glancing at the sum of his proof; which I wish they who affect being his detractors would deliberately weigh and examine, before they pretend to reject and pre-

judice others against it. He shews, that the descriptions of natural things, and the words and expressions every where used by the inspired writers when speaking of them, are, when fairly examined, suitable to and founded upon the exact physical construction of the system *. He demonstrates, that idolatry took its rise from a misapprehension of revealed natural philosophy ; and consequently, that the names of the Pagan Deities, mentioned in the sacred records, bear an express analogy to the mechanical powers and operations of the system. He proves, that their idolatrous typical service of these Deities, was all a figurative exhibition of these material operations, but transferred by these idolaters and made powers and attributes of their false gods. He shews, that the Jewish typical oeconomy of worship, on the contrary (besides its figurative exhibition of future events of infinite importance) was exactly calculated to reclaim all these Heathen misapplications, and to instruct and confess that these powers belonged only to JEHOVAH ; who had composed the mechanism of the world

* See *Letter to a Bishop, concerning some important discoveries in Philosophy and Theology*: printed in Quarto for HENRY WOODFALL, without Temple-bar, 1735. and in Twelves, 1747.

so as to exert them. With the same elegance and justness he discovers, that the miracles, wrought from time to time, were of such a nature, and so suitably interposed, as to convince the idolatrous Heathens, and the wavering Jews (who were always apostatizing into their opinions) by controlling, reversing, or rendering miraculously destructive the powers of nature, under all the different views they formed of the great operations which supported nature, and which they classed as different Deities, or different attributes of their Deities. For tho' all the ancient nations worshipped the heavens, yet each nation pitched upon a particular view of their universal government of the world, and denominated their gods, temples, cities &c. accordingly: by which means each nation in a manner affected to appropriate their universal Deity to themselves, striving who should engage most of his favour as a tutelar god and saviour. In this they affected to copy from the divine oeconomy: for tho' God was and is the common father and supporter of mankind, yet, for reasons worthy of divine wisdom, he assumed a particular care of, and exerted a system of special providence for the Jewish nation

nation and their progenitors. Upon the whole, he chains Revelation and Nature together, in a way never comprehended before ; and establishes a most glorious analogy between the powers and operations of nature and the system of spiritual revealed truth, so important for man to receive and understand *. But this last belongs more especially to his writings and character as a divine.

As a philosopher, his discoveries (until they are disproved at least) intitle him to the character of one of the greatest, and at the same time, most laborious genius's the world is acquainted with. They are likewise of that excellent nature, that they lay the foundation, and open the way for carrying on that system of knowlege to greater perfection, than he himself either foresaw, or could have imagined. I can with the greater freedom give him his due honor, as I don't hold his judgement infallible in many instances ; and can without biafs be sensible of what I think mistakes in him. But in the main, his writ-

* See *Creation the ground-work of Revelation ; Revelation the language of Nature, &c.*

ings, by way of eminence, above any human efforts I ever saw or heard of, deserve the name of *Novum organum scientiarum*.

You'll readily agree with me, SIR, in thinking it worthy of a public remark, That of all the attacks which have been lately made upon him and his friends, not one of these opposers has ventured upon an examination of his philosophy : but they have worked upon the critical part of his writings ; where there was most room for cavil and evasion, and which would tend most to prejudice those, who were strangers to him and his writings, with the seeming uncertainty and deceitfulness of his pretended discoveries.

I cannot imagine, how these gentlemen could be insensible of the unfairness and dissingenuity of this method. Suppose the critical evidence for this or that manner of translating a Hebrew word had been equal on both sides ; yet his or his friends sense, corresponding with the justest idea of natural truth, was more than sufficient to cast the balance in their favor, with any person who did not think Revelation was written by too low and

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contemptible pens, to pay any regard to the physical justness of their stile.

You'll allow me also to remark, that in the age when the ideas of natural religion ran highest, and the arguments in defence of it were carried on, not with reason, but audacious insolence and profaneness, and supported by pretensions to unparallel'd discoveries in natural philosophy, (while the contemptible *Scriptures* were supposed to be written, not for the wise and the learned, but *ad captum profani vulgi*) he has given the finishing stroke to that cause. In this light, I must be allowed to class along with him the inimitable Dr MANDEVIL; who has illustrated the scripture account of the state of human nature, with as convincing demonstration, as the other has the inspired discoveries given us of natural philosophy.

It is the great excellency of this philosophy (tho' I'm afraid a very forbidding one with many) that it is inseparably connected with Revelation; so that none can embrace the former, and reject the latter. Divine wisdom, to the confounding of our mighty, penetrating,
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ing, independent capacities, has so compounded the truths which admit of demonstration with these which depend upon his own veracity and infallible testimony, that no adversary can separate them. They partake of one another's evidence in the fullest manner; they are woven into one another, so as to make one web; and they as faithfully correspond, as the reflected image does to the object.

One of the ridiculous and monstrous abuses, which all preceding systems of philosophy led into, has been the explaining Creation itself by the standing laws which they imagined ruled Nature invariably, in its present disposition. Tho' SIR ISAAC himself has not made this application of his Laws of matter and motion, yet his followers have fallen into the same abuse. Our philosophy lays an unsurmountable bar in the way of its being extended to such imaginary and impious conjectures.

Every one, who has a just idea of the mechanical philosophy, must readily determine, That matter could no more arrange itself into its present mechanical order, than it could

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give being to itself ; for its powers are the consequence and not the cause of its composition. When constructed and put in motion with the full exercise of all its powers, it could not produce one organical body either vegetable or animal, nor generate the rudiments of them. It could not, from a mingled mass of materials, have effected the separation of fluid and more fixed parts, which we now enjoy on our globe ; without which, it could not have reared organical bodies, and many other productions, when prepared for the influence of the machine. It cannot change its own course, neither fall into disorder or waste : without divine interposition, the frame of Nature must continue eternally ; and without divine Revelation, we could never have known, that it did not exist from eternity. It is of obvious and necessary use, in giving a just direction to philosophical researches, to know upon proper evidence, that there is a Creator ; and to know what parts of the frame of Nature could not be originally the product of its powers, but were the elegant modifications of the Great Architect, in which the powers of Nature are to work out its various productions.

As to the following *Essays*, I shall say but little. Tho' the plan be new, I hope it will be universally approved, as it is certainly regular. The only way to attain the knowledge of any piece of mechanism and its powers, is to be acquainted with the distinct materials and members of which it is composed, and to understand their proper bearings and adjustments ; without this, we shall be amused with mysteries, where there are none. The *Essays* have another property, which, I flatter myself, cannot fail to recommend them. They are short ; which is the best recommendation they can have, next to their being well executed. If they do not give satisfaction in this latter respect, it is not for want of inclination in the Author to satisfy his Readers. But if I have contributed to point out the way to a more just and general acquaintance with natural truth, I shall rejoice to be supplanted in the prosecution by some abler hand.

Tho' they are denominated *The principles and properties of matter and motion*, yet I am obliged to make several of these properties negative ones, in order to strip the materials of the machine of those false properties, which

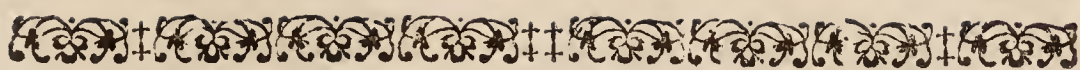
do not inseparably belong to it. An anatomist would not readily make it one of the properties of the bones of the leg, that they move the body ; tho' they are for that use, when articulated, mounted with ligaments, muscles and nerves. On the above-mention'd account, I have been led to reason a little under several heads, and to use a little more illustration than is usual in writing Aphorisms ; which form I have endeavour'd to imitate, because it favoured brevity most.

If this attempt, as far as it is brought, SIR, meet with your approbation, and that of some other gentlemen whose judgement and impartiality I confide in ; I shall hope it will be better received by the Public, than I should otherwise be vain enough to expect. I am, with respect, SIR,

Your obliged and most humble Servant,

Newton, Dec. 27, 1753.

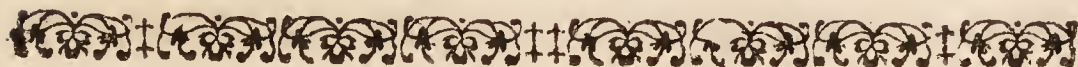
A. WILSON.



N U M B E R I.
T H E
P R I N C I P L E S
A N D
P R O P E R T I E S
O F
M A T T E R.

ἌΤΤΟΣ γὰρ μοι ἔδωκεν τῶν ὄντων γνῶσιν ἀψευδή, εἶδεναι
συστάσιν κόσμου, καὶ ἐνεργεῖαν στοιχείων.

WISDOM, Ec. vii. 17.



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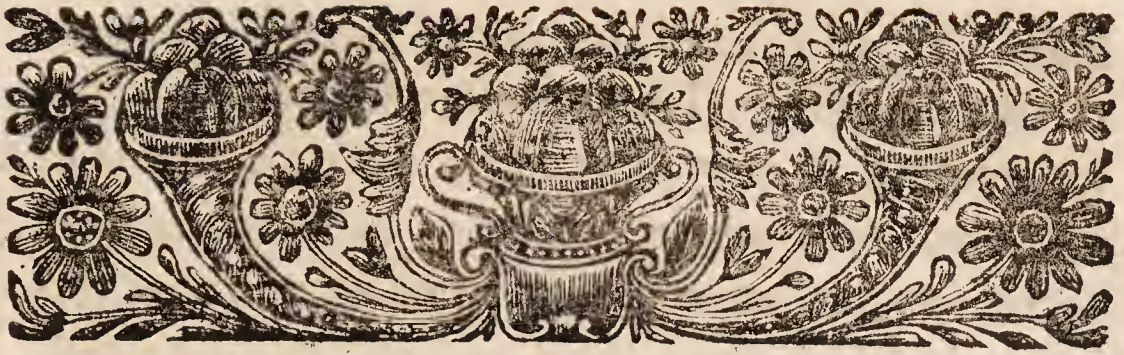
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T H E
P R I N C I P L E S and P R O P E R T I E S
O F
M A T T E R .



H E philosophers have been very curious and minute as to their inquiries into the mathematical laws and proportions of the motions of the larger bodies in this system; which commonly go under the name of gravitation, attraction, projection, &c. But they seem to have been very unsuccessful or defective, as to their discovering the natural or mechanical principles and causes of all motion in material substances. As local motion can belong only to material bodies,
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I am inclined to think it must be produced by material principles. The procedure of nature cannot be creating of new substances, but is a course of motions, revolutions, changes, alterations, and variations in matter already in being: so that this universal frame seems to be nothing but a complicated train of motions, absolutely depending upon the immutable constituent properties of matter. In a word, the principles of matter and motion seem to be one and the same. Therefore it is hoped the following *Essay* to state the first principles of natural philosophy, will meet with a candid and open reception from the public in general, as it is no way abstruse; and from the searchers after physical truth in particular, as I hope they are agreeable to the profound simplicity of nature, and the mechanical justness of all her operations.

The universe appears to be one great machine, fitted and disposed to perform all the operations which are carried on throughout the whole. No one part of it should be considered as acting, without being acted upon; and no individual can be considered as an agent, without being a patient. It is unphilosophical to say, matter in general, or any part of it, has essential or separate properties, by which one part acts upon another: it is the essential property of no one wheel in any machine to move its fellow, tho' in consequence of its
being

being placed in the station it is fitted for, it acts upon its fellow, because it is acted upon.

Just so it is with the whole system of nature. You cannot take up any parcel of matter and say of it, This has essential separate properties, which impower it to be a natural agent. A philosopher ought to consider it as a concrete, with a certain disposition of its parts, liable to be acted upon by the subtler parts of the machine, which cannot be restrained from it by art. And it may as justly be alledged, that it is the essential property of animal substances to live, or of vegetables to spring, as it can be said, that it is the essential property of the loadstone to attract. Nothing therefore can be more conducive to the promoting a true acquaintance with the operations of nature, than to consider what are, and what are not, the essential properties of the first principles of matter.

I. First then, matter must be composed of first principles : and these may be called units or atoms of matter. Nothing to me appears more sceptical in philosophy, than to assume it for a first principle, that matter is infinitely divisible: which is asserting in other Words, that matter has no beginning of substance ; that there are no limits between matter and nothing. That there cannot be such a thing as an unit of matter, is to
E maintain,

maintain, that matter has an infinite property. To say that any parcel of matter is finite, and at the same time that its component parts are infinite, is indeed philosophy baffling itself, and maintaining contradictions. Time is made up of a perpetual succession of years and days, and is measured by hours, and minutes, and moments : and it would be just such a metaphysical truth to tell us, one moment of time may by dividing be lengthened out into a thousand ages ; as it is a physical truth to aver, that a grain of sand, by the infinite divisibility of its matter, may be rarified and enlarged unto the bulk of a planet. Nothing can be more shocking to reason, or even to the ear, than *Eternal Time* ; and infinite divisibility, when examined, must be found just as absurd. Concretes, in which form matter is made subject to our senses, can no more be without such first principles, than numbers in arithmetic can be composed without units.

II. Atoms must originally subsist in numbers, which cannot be diminished or increased ; it is equally impossible for many to become one, as it is for an unit to be multiplied : so that the original number of atoms is as invariable as their figures or sizes. An atom may as soon be repressed into nothing, as two can be made to coalesce into one unchangeable substance. Number is the fundamental

mental basis of motion and changes in matter. An atom cannot act upon itself, nor communicate action, impressed intimately to its substance tho' never so large ; but a concrete can and does impress its own inward parts, in a mechanical proportion to the power which acts upon its surface. Therefore it is in vain to say, that all atoms must have parts, tho' the component particles of all bodies are small enough, and rigid enough, to resist or elude all separation by the agency of matter. If any body, tho' never so small, has numerical parts, their cohesion must be mechanical ; and nature can do nothing but what it can undo again, under certain circumstances. To this purpose, *Sir ISAAC NEWTON* closes a fine inquiry into the nature, laws, and constitution of matter — “ All these things considered, it
 “ seems probable to me, that God in the begin-
 “ ning created matter in solid, massive, hard,
 “ impenetrable, moveable particles, incompara-
 “ bly harder, than any of the porous bodies
 “ compounded of them : nay so hard as never to
 “ wear or break in pieces ; no human power
 “ being able to divide what God made one at the
 “ creation. While these particles continue intire,
 “ they may compose bodies of one and the same
 “ nature and texture in all ages : but should
 “ they wear away, or break in pieces, the nature
 “ of things depending on them would be chang-

“ ed : water and earth, composed of old worn par-
 “ ticles and fragments of particles, would not be
 “ of the same nature now, as water and earth
 “ composed of intire particles at the beginning.
 “ And therefore, that nature may be lasting, the
 “ changes of corporeal things are to be placed
 “ only in the various separations, and new
 “ affociations, and motions of these permanent
 “ particles.” *

III. Such an atom or unit of matter must have
 dimension ; it constitutes its own space wherever
 it is, and occupies it. The idea of a solid and
 extension are inseparable ; but that of division
 and a solid are irreconcilable. Solidity among
 concretes is only comparative and imperfect ; but
 it is as great a contradiction in terms to apply
 division to a proper solid, as it is to apply it to
 the space of a body abstractedly or mathematically
 considered, which is nothing. Tho’ two things
 may be separate one from another, yet one thing
 and nothing are equally indivisible. Dimension
 in bodies has proportion, and may be considered
 less or more ; and the extension of a larger body
 may be a proportion for several smaller bodies :
 but the idea of parts and divisions has no connex-
 ion with extension ; and as little with the matter

* NEWTON’S *Optics*.

which

which occupies it, unless it is a concrete. Division is an idea which properly belongs to number, which is a consequence of the existence of matter, and a different one from space. There is therefore no connexion between matter having dimension, and its consisting of parts; or one body is not many in respect of another of the same kind, because its substance is larger. To take an example from units of concretes, of which nature is composed in a secondary sense; one egg may be larger than another egg; but tho' the one may be thrice as large as the other, yet the bigger is as much one as the lesser, and cannot be supposed to be three. There is a great difference between thrice as much matter being contained in one individual, more than there is contained in another individual, and the larger one's being three individuals. Just so it is with respect to the first order of units, or the atoms of which all concretes must be composed. One atom may be several times larger than another atom, yet it is as much an unit as the other, and cannot be divided; tho' if any one please, he may conceive of its dimensions, as having distinct room for a concrete of several smaller atoms; but even that gives the extension of the large atom no parts further, than by supposing a body with parts to occupy its place. Now because the larger atom is several times more extended than the atoms of a concrete
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of its size, the one atom is not therefore many, because the concrete is so. Therefore every atom or unit of matter has extension, which we may suppose to have mensurable proportion; but the atom itself is incapable of division, because

IV. An atom does not consist of parts. It is not composed by one body's being applied to another body, which either art or nature can separate, or which can be separated even in imagination. There can be no incroaching on its substance, but by annihilation. Tho' we should suppose two bodies equal in size, the one a concrete, the other an atom; because the concrete may be dissolved into a thousand inconceivably smaller parts, yet that can give us no idea of the atom's consisting of as many parts strictly applied to one another. It is an atom, has no cohesion of parts, because it has no parts; however conspicuous its dimensions may be, yet it is one and unalterably the same. What gave being to it in that size and form can only alter it. But nature, or matter acting upon matter, combining, dissolving, and changing the forms of things, cannot change an atom.

V. An unit of matter cannot be pervaded. Its substance is without parts, and so without pores or interstices. It can be pervaded by no fluid, tho' never so subtil. It occupies its own space or dimensions,

sions, and nothing else can be said to be or exist where it is. Pores or interstices belong only to concretes, or atoms forming a mass by adhering to one another in any number. Such concretes as these must have interstices between their atoms, and may be allowed to have these interstices filled with a subtil fluid; or if there is any necessity for still retaining the paradox, may have space occupying them, as well as they occupying space. But this cannot be the case of an unit: so far from it, that space or dimension is an essential property of matter; and it is impossible to have any conception of the two separately.

VI. Every unit, in consequence of its former constituent properties, enjoys perfect solidity. Atoms of one shape and size cannot be heavier than one another. Weight, subsiding, ascending, and parcels of matter taking different stations of one another, or weighing differently, are the effects of matter acting upon matter, and are performed according to the laws of different solidity, &c. Which subsist not among atoms, further than as to their different shapes and sizes, by which another material agent may be applied to them in different proportions. But matter subsisting in atoms, and acted upon by the agent which produces gravitation, would precipitate or subside equally, because in units there can be no difference of solidity. Atoms of the same figure
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and size, or of different shapes and sizes, must be to one another, as gold is to gold, and not as gold is to silver, or any other metals, which differ from one another in their specific gravities.

VII. Such atoms must be absolutely opaque. Pellucidity is opposite to perfect solidity, and supposes interstices, and these in a certain direction. The transmission of light in direct lines through the pores of concretes, is such a singular conformation of its solid parts, and interstices, as deserves a separate Treatise: but atoms have no pores, so nothing can penetrate their surface. And when reflexion of light is sufficiently understood, it may be considered, whether atoms subsisting as such (that is, not adhering in forms) could in any quantity become visible.

VIII. Atoms are absolutely inert, and can neither conciliate motion to themselves, nor continue in motion longer than they are impelled. They are absolutely passive, and cannot be supposed to move one hair's breadth after the impelling force is restrained. To give matter an eternal power of changing its place, in consequence of its being once disquieted, to me appears most unphilosophical.

IX. Units

IX. Units are at the same time capable of perfect mobility. For as they cannot move themselves, or alter their place ; so they have in themselves not the least resistance to motion, or to be continually altering their station while they are impelled. Therefore in our system, the matter which subsists without any cohesion of its atoms must be by far the most active.

X. Atoms can have no elasticity. They have no parts to recoil, and to reverberate upon their being impelled. That property of matter implies parts, interstices ; these interstices replenished with some active fluid, and a resistance to motion : none of which atoms have.

XI. Atoms can have no attracting or impelling powers, &c. To suppose them to have such, is to destroy another property, which by the philosophers is ascribed to matter ; namely, the *vis inertiae*. For if the first principles of matter attract one another, that is endowing them with a *vis motus*, or a power of moving towards one another. If such a thing there be as attraction, it must be either a material property, or a spiritual one. If it is a material one, an atom cannot be possessed of it. It cannot move itself. It consists of no parts, therefore cannot detach subtler parts to draw its fellows into contact. If it is a spiritual operation,

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then

then it is no property of matter at all. And if the first principles of motion in matter be universally spiritual, then there is no need for mechanical agency in matter, or of second causes. If we say, there is use for mechanical agency in nature; then it is very absurd in philosophers to fix unmechanical principles, until they are certain and can demonstrate, that they have traced the utmost length that nature in a mechanical way can go. If attraction be a principle or radical property of matter; how is it, that it can be weakened, suspended for a time, yea and quite destroyed? If it be a power determining matter to matter, and as real a property of matter as solidity, &c. how is it, that this property can be over-powered and destroyed by matter's acting mechanically upon matter; which must always be in a consistency with and subservience to its original properties? Yet in fact we see the force of fire can suspend the strongest attractions, as in the fusion of gold; when that metal, which has such strong attraction of its parts, appears in the form of that metal, which has the least and weakest of any, namely, quick-silver.

XII. Neither can the first atoms of matter possess a power of gravitation. That principle is yet more opposite than the former to a *vis inertiae*; and the laws of gravitation and attraction seem even directly opposite to one another. In attraction, that
power

power is weak enough not to exert itself, but when the atoms of matter are in immediate contact with one another, or are at least verging upon it; yet when they thus approach one another, they acquire an obstinate cohesion. On the contrary, matter attracts matter in gravitation at infinite distances; and that passion increases their velocities, the nearer they approach one another: yet when they come into contact, notwithstanding the rapidity with which they rush towards one another, they acquire no adhesion at all. One who would consider these two dispositions of matter (if such there be) in a natural way, would think, that the one would naturally pass into the other, and that they both proceed from the same inclination; so that gravitation would naturally end in that adhesion, which is the effect of attraction. But it is not so. From all we can understand of the units of which matter is composed, a mass of them, lying together, unacted upon by a mechanical material agency, would neither attract, gravitate, nor take place of one another; as in our system bodies of different gravities do.

XIII. Units may differ from one another in their size. This property it is, which lays the foundation for all the variety of forms and diversity of substances, with their singular properties when thus combined, which are so useful in the

universe. This property, I say, is the source of all that variety, when joined with

XIV. The diversity of figures in original atoms. These two modify the other general properties of matter, so as units, combined according to their different sizes and figures, present us with that profuse and beneficial variety of substances, which we see in the creation. Without these, it will be difficult to account for them. These leave small hopes of the transmutation of metals, &c. especially the more pure and simple ones. For if the units of gold, silver, or quicksilver be essentially different in their sizes or figures, or in both of them; no art or mechanical agency can change the units of matter, because all the properties of atoms are

XV. Unchangeable. To alter an essential property of any atom is to annihilate it, and so to disannul its properties altogether. This is a firm basis for mechanical agency. For if the substance of the first principles of matter were not permanent in its properties, but mutable upon external impressions; nature would go on uncertainly in her operations, and could not be uniform in her effects. Therefore we have no reason given us to apprehend, that matter has any primordial principles, which will yield to external agencies.

agencies. An atom and all its properties are coeval, and must be of equal duration ; because an atom and its properties are the same. We can have no apprehension of matter, but that it is substance ; and if we would define substance, we have no characteristic of it, but its properties. Therefore to give matter properties which can be dissolved by any agency, besides that by which it exists, is to leave us no certain principles as to matter at all. And hence we must necessarily conclude likewise, that

XVI. All the properties of matter are material, and not spiritual. If the contradicting the former disannuls all certainty, as to matter itself ; the denying of this would leave us in equal uncertainty as to its operations. To endue matter with properties which do not necessarily depend upon its being substance, is to possess it of a soul and spirit : and to subject soul, or these spiritual properties, to the laws of material mechanism, is absurd. Nature proceeds mechanically, so far as we can trace it : and tho' our senses are limited as to the *minutiæ* of that mechanism ; yet we are certain that matter does exist in such forms in the universe, as will assure us the mechanism may go on further than we can describe. Matter is a mechanical, and so a necessary agent ; this we ought to call nature. But a spirit is a voluntary,
and

and so a free agent ; and these ought not to be confounded. The philosophy of occult qualities in matter, and of properties we have names for, but can form no ideas of, from the knowlege we have of substance, is certainly refined upon, by introducing the immediate agency of a first cause in all these cases. This has lately been advanced by a great prelate and an ingenious philosopher : and to be sure it cannot be contradicted by any who maintain these uninvestigable qualities of matter. But I cannot think it is doing any honour to the Deity, to make him a necessary agent in the course of nature, by imposing these laws upon him, before we are certain whether material mechanism reaches unto them or not. Voluntary and necessary, are the distinguishing characters of the agency of spirit and matter : and to confound their operations, is exalting the one, and debasing the other unduly.

XVII. All the properties of matter are natural, every one of them fit to act and to be acted upon in a mechanical way. They are such as can all of them be adapted to the known principles of mechanism among artists. Latent qualities are destructive of that sort of agency. Tho' matter is not infinitely divisible, yet it is certain, its primordial atoms are indefinitely small ; so as the grossest of them are far beyond the reach of our senses, even
with,

with all the assistance which art can furnish them. At the same time, our organs are so finely machined, as to be subject to the impressions of the smallest : from which several useful corollaries might be deduced. But because the units of matter are so subtil as to elude our senses ; it does not therefore follow, that we can have no certain knowledge of them, or of their properties. From the knowledge of concretes we may certainly discover, what are the general unvariable properties of their constituent atoms. Every concrete enjoys two distinct kinds of properties : the first are such as are inseparable from it as matter, and these properties belong to every atom of which a concrete is composed ; the second are such as are naturally produced from matter, being variously combined in concretes. These are the natural, mechanical, or consequential effects of the original properties of atoms adhering in various forms. These cannot be however the original properties of matter, tho' the original properties, being all mechanical, naturally produce them. Therefore we should observe the strictest caution, lest we ascribe the different properties, which matter acquires by being composed in different forms, unto the first atoms themselves : for one may as justly conclude, that the units of which ivory are composed are white, as that they are elastic.

These

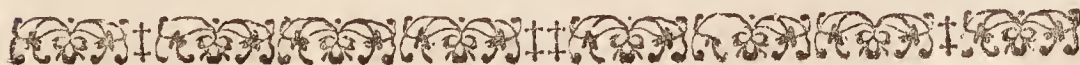
These being the fundamental principles of matter; if we would understand the nature of its operations, we must proceed step by step, examining the different conditions in which it subsists in the world: what are the distinguishing characters of it in its different forms; how motion is produced and supported; what are the different circumstances requisite to produce, maintain, and direct the motions of bodies; what is done upon their surfaces; what is a doing within them, or what it is they are said to do, considered as unorganized; what matter performs, and by what agents, in organized bodies; and how far its powers extend in sensitive ones. But what I have said above is sufficient for my present purpose; if it establishes the necessary instruments for supporting and maintaining that inimitable series of variety, which nature displays in her operations; which is amazing to all, and which it is the wisdom of the true philosopher to understand. All our inquiries are into the agencies of nature; but we can never comprehend them, unless we are acquainted with the principles which alone can produce them.

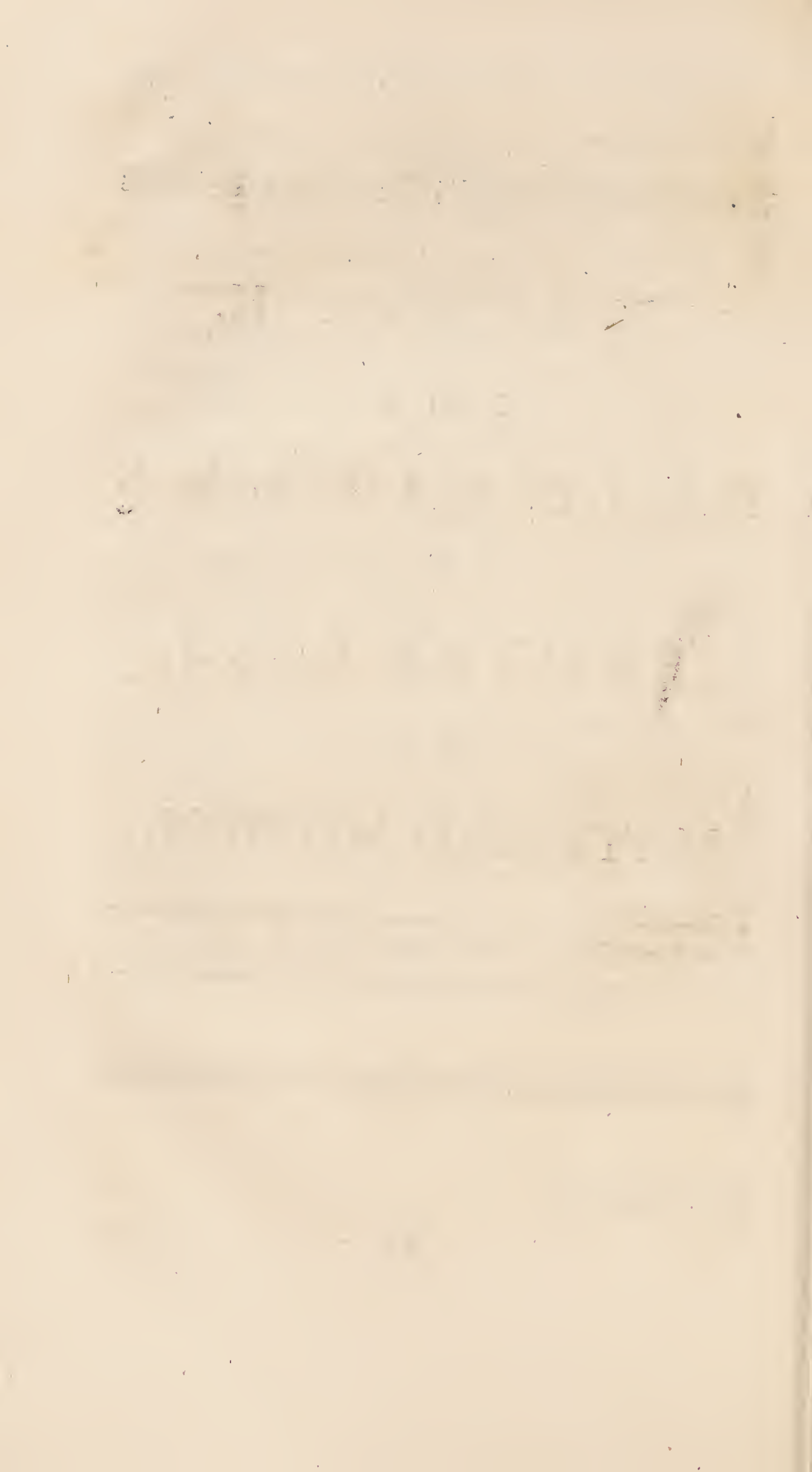
NUMBER



N U M B E R II.
T H E
P R I N C I P L E S
A N D
P R O P E R T I E S
O F
M A T E R I A L M O T I O N.

Materiem superabat opus. OVID. Met.







T H E
PRINCIPLES and PROPERTIES
O F
M A T E R I A L M O T I O N.



THE whole frame of nature is a compound of material substances and their motions. Matter without motion would be a lifeless barren mass; and local motion without matter cannot be. Motion is the great and universal soul or principle of life in matter, the parent of all the forms or modes of being, into which matter is diversified, and in which it acts. What I call modes of being are the different appearances and properties, which are not originally inherent in matter, abstractly considered, without
G 2 any

any orderly motion produced upon it. The substance of an animal and a vegetable have the same absolute material properties, defined N. I. which are inseparable from both, and common to both : but the characteristics, which distinguish the one from the other, are their conditional properties, or the various products of differently modified motions, collecting, arranging, and supporting their substances in different modes of being.

That there is an universal principle of motion throughout the system, is self-evident. That it must have a continuing cause, is a necessary consequence drawn from its existence. Whether this cause be spiritual or material, needs be no question ; when we know, that matter moving can be the cause of motion in matter at rest ; and our comprehension has no intimation given it of any other natural cause, able to produce or preserve such motion. I shall therefore endeavour to state, what must be some of the necessary universal properties and effects of motion, mechanically supported.

I. Local motion is essential to material action. As we can apply the idea of space or place to matter only ; so change of place can be ascribed to nothing but matter. The action of intellectual powers seems to be quite of a different nature : for tho' in some sense the human body may be called the de-
termined.

terminated sphere of the mind's activity ; yet its actions require no change of place. On the contrary, it seems to have an unlimited power of constituting within itself a comprehension or conception of all the properties belonging to matter, or its actions. So that the mind, without being able directly to exert its influence upon matter, or to act as matter does, has as free and commanding an use of its properties, as the hand has of a ball. Here is an equal and wise partition, between the body and the mind, of the use of matter and its properties : the one is constantly either acting upon, or immediately affected by them ; the other is constantly deriving the intimations of these accidents, and has the command of their images, but no action, that interferes with or can affect the material objects which yield them.

II. Tho' the absolute properties of matter be essential to the being of matter ; yet all the knowledge we can have of these properties is relative, and depends intirely upon the actions of matter. In other words, our senses, which convey all the images we can have of matter, are supported and impressed by material action. Our knowledge of matter depends intirely upon the reflection its actions make upon our senses ; and as by looking into a glass, we know no more of an object than the glass represents ; so we can know no more about
matter,

matter, than its actions inform us of. The Creator has set a bar upon our attaining any more knowledge of nature, than is conveyed in that way. Infinite wisdom has conveyed sufficient knowledge to us, without the least glimmering light of the manner, in which creating power knows, passing along with it. The Creator intuitively and potentially knows what constitutes the essence of matter. We can only be informed, by its actions upon our senses, what are its material properties. So that it is one of the fundamental properties of motion, to reveal the existence of matter in all its modifications, to sensible and intelligent creatures.

III. As impulse is the only material cause of motion, which we know or can comprehend ; we must determine it to be the cause of all motion, and continuance of motion in the material world. That is one certain and universally known cause, and neither the properties of matter, nor observation, afford us the knowledge of another. What divine power can do, or has done, is out of the question ; I speak only of the power he has constituted to act in the frame of nature. It is one of the infinite differences between the human and divine mind, that the latter has the absolute power of what we find wisely denied the human mind, according to §. I.

IV. All

IV. All motion is relative. We determined number to be one of the essential properties of the material world. Now motion can only be absolute, where an unit only exists. In which case, its supposed motion can admit of no mensuration; not even that of its own dimensions: for multiplying its dimensions to know the length of its motion, cannot be done, without being first possessed of the idea of plurality, which is acquired by matter's existing in number. As absolute motion could not be mechanical, and could never have given the ideas of mensuration, distance, &c. so useful to creatures; so it would also have been abortive and inefficacious, which no motion or power of motion is. Suppose this whole system should be continually traversing infinite space; that is no motion to us: we feel no change, every thing continues just as it was, and no effect is produced by it. But with us the ideas of motion and change are inseparable. Motion can be of no effect unless it be relative. Of what use relative to the system, to which they once belonged, must the first rays of light be; which, according to the philosophers, have for five or six thousand years been travelling with vast rapidity into infinite space? Motion being the universal principle of life in nature, would, without any further evidence, incline any unbiassed person to presume, that no motion existed without producing some

some relative effects, subservient to the support of the frame of creation in general.

V. Tho' all motion be relative, it could not be so unless it were real. But as we have no names, except such as are relative or comparative, to describe it by; all we can say of it is, That matter in motion is continually shifting its station, and occupying new room.

VI. As matter is not divisible *in infinitum*, so neither can motion be so. There is a point or *minimum* in motion, as well as an atom of matter. The same way of arguing, which proves that a snail might out-run ACHILLES, or that two curves may be eternally approaching each other without a possibility of their ever coming into contact, will prove that two cannon balls at 50 paces distant from each other, and moving with the greatest velocity directly towards one another, will never meet. The *minimums* of motion are as remote from our senses, as the atoms of matter are. But as massive matter is the object of our senses, and convinces us of the existence of its insensible component parts; so the portions of motion, which are subject to our observation, convince us of the insensible divisions which constitute it: and these insensible elements, I may call them, of motion are determined by the following proposition.

VII. Mo-

VII. Motion has no sensible intermission; yet it must be performed by real intermissions, that is, successive impulses and stops. This is the necessary consequence of a succession of impulses being the cause of continued motion. Motion to the eye is like the edge of a polished instrument, smooth to the naked sense, but when more strictly examined, ragged and serrated. This is more evidently demonstrable in sound, which, tho' it is perceived without any sensible remission, is excited by distinct vibrations and percussions. In like manner, any body turned quickly round an *axis*, tho' extended from its centre by a pretty long *radius*, represents to appearance an uniform circumference, existing in every point at the same time.

This may possibly appear a very indirect way of deducing the mechanism of matter; but it certainly leads to a conclusion, which establishes a primary fact in the organization of the system. For if motion is continued by impulse, there must be a constant succession of impulses: these impulses cannot terminate in a mechanical origin, unless fresh matter be constantly brought into the direction of these impulses. Therefore every new mass of matter, deflected from a former into that new direction, must in that deflection or change of direction undergo a change; which,

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tho'

tho' insensible, we can call by no other name than an intermission. So that motion by continued impulse necessarily infers a circulation of matter.

VIII. Time and length are two ideas inseparable from all motion. Geometricians have been at great pains to ascertain the proportions these bear to one another, in some particular kinds of regular motion. But these *Ratios* are not essential to all sensible motion, tho' they are established as to some. This yields us a distinction, which may be of some use; namely, the difference between an essential relation and an established one. Time and length are essentially related to motion; but their *Ratios* to one another is only established. The earth might have rolled round its own *axis* in twelve hours, and round the sun in half a year; but the double of these times is the established course. The successive durations of moving matter, in the successive spaces the moving body occupies during its motion, is properly what is meant by the time and the length of a body's motion. These are always ultimately related to the primary fountain of motion by impulse, and their *minimums* are the same as those in the two preceding sections. Time is properly a succession of durations, and these durations are ultimately the same with the *minimums* of motion. Infinite wisdom and power, which contrived how to compact the insensibly-small atoms of matter

ter into solid sensible bodies, has shewn the same skill in dividing duration, (tho' an indivisible-like idea) by motion into insensible points.

Tho' time, in this light, be an obvious and necessary property of motion, and the ideas of the two are inseparable in their natures ; yet this abstracted view could have been of no use to us, if infinite wisdom, which knows how to convert the most obscure principles into the most sensible benefit, had not exhibited in nature an established sensible mensuration of time, fitted for all human uses and applications. The public, in my opinion, is much obliged to the ingenious and learned *Mr. KENNEDY* for the *éclaircissement* he has endeavoured to bring that matter to.

IX. All motion must necessarily be in some direction. Direction can be only of two kinds, either in a straight line, or in a curve. Of the latter there is a great variety between a circle and an *hyperbola* : but the profoundest skill in geometry can never demonstrate, that two simple powers, such as projection and gravitation, can make any body move in any of these curves, save that of a circle. Philosophers say, the power of gravity upon the surface of this earth causes a body to descend towards it, at the rate of about 16 feet in a second of time. The power of gravity is about 23
H 2 times

times stronger upon the surface of the sun; therefore the particles of light about the surface of the sun, left to the sun's attractive power, would precipitate towards it at the rate of 368 feet in a second. The power then, with which they are projected into space, must be that of 368 feet in a second, added to the velocity with which they move outward. A power of projection, applied outward from the sun's centre of gravity, just equal to 368 feet in a minute, would keep the particles of light suspended, so as they could neither recede from, nor approach to, the sun. That degree of power, applied in the direction of a tangent, would make them move round in a perfect circle; but that power, applied in any other proportion, either below or above 368 feet in a second, and in any conceivable direction, could never bring the form of the curve they would describe into any one of the sections of a cone; but it must describe a curve, either gradually bending more and more to the centre of gravity, or gradually extending and approaching more and more towards the direction of a straight line. *Sir ISAAC NEWTON* himself has shewn, that if the centripetal power acts after a certain manner with the increase of distance, a body may describe such a curve line, that all the lines, drawn from the centre to the body, shall be equally inclined to that curve line the body moves in round its centre of gravity. Whatever force of projection is applied, above what is sufficient

cient to cause a body to move in a perfect circle round its centre of gravity, must cause it to move in a spiral curve, regularly extending in proportion to the overplus of force, which would keep it always at an equal distance from its centre, and the gradual decrease of the centripetal power: no conceivable force and direction of projection can ever bring the orbit of a planet into an elliptical figure. I cannot apprehend any reasoning more fallacious, than to argue from the properties of a figure to the *ratios* of powers; and to conclude, that, because at that point of an elliptical arch, where a line drawn from the centre falls at a right angle upon the curve, the arch there begins to bend more toward the centre — therefore at certain points, the powers of gravitation and projection exchange an increase and decrease of their activity.

X. No mechanical motion can subsist without a *plenum*, wherever such material motion subsists. This proposition is so necessary a consequence of motion's being carried on by impulse, that it needs no other demonstration.

XI. It follows also of consequence, that the system of material motion must be limited by boundaries. Without these, motion by impulse must cease, for it requires a *plenum*.

XII. Every

XII. Every body in motion must have the virtue both of a cause and of an effect. No body can move in a *plenum* without putting others in motion, and more than it can move without being impelled itself: but if there were no fixed limits to return and circulate the activity of the impulses of matter upon matter, mobile bodies at the extremities could not obey the impulses given them, by repeating them upon other bodies. It is not my business here, to obviate the things that may be said to make the supposition of such boundaries absurd and monstrous. I mention it here as a necessary condition of matter moving by impulse; if any person will shew that it is not, I give it up.

XIII. There must be a centre of all mechanical motion, which must communicate impulse and direction to all other motions. The centre of motion must be the same with the centre of the boundaries which confine and reflect motion. Such a common fountain is as necessary to mechanical motion, as a *plenum* or boundaries are.

XIV. The matter, which is originally concerned in carrying on all motion, and which acts to and from the common centre, must act in different conditional properties, but must consist of the same kind of elementary principles. I purpose it shall be the subject of another *Number*, to examine, what
are

are these conditions of matter, which qualify it for acting necessarily or mechanically, as it does in this system. Therefore I take no further notice of it here, than as it is a necessary requisite in mechanical motion. We have found above, that there must be a circulation or change of directions in such motion. Now matter, in the same condition, cannot act regularly in opposite directions, because it would have an equal tendency to both : but in different conditions it can have ; and we shall in its proper place shew, it must have a *nifus* to opposite directions. Again, it could not change its direction, unless it change its properties, and be transmutable into the different conditions, which the opposite directions require. Therefore, that *congeries* of matter, which is the original fountain of motion, must have the same elementary properties, that is, must be homogeneous.

XV. Matter, from which all motion is originally derived, must be in a fluid state. I mean by a fluid state here, that such matter has no cohesion between the particles which constitute its different conditional properties. This is so obviously necessary, that it needs no demonstration.

XVI. Motion ought to be divided into sensible or apparent motion, and insensible or occult motion.

tion. The running of water, the descent of any weighty body called gravitation, the course of projectiles and other moving bodies, and the voluntary motions of animals, &c. are apparent motions. The propagation of light, the pressure of the air, the action of the magnet, the power of electricity, are insensible motions, save by their effects.

XVII. All sensible motion must have insensible motion for its ultimate cause. When the magnet, or an electrical power, exerts its virtue on another body, we conclude there is a moving power, distinct from the body affected by it. When a person moves a member, we conclude it is produced by some insensible motion, communicated to that member, tho' we ourselves are not conscious of it.

XVIII. The three universal and inseparable effects of motion upon all terrestrial bodies, are cohesion, weight, and power.

XIX. Every body is not always in sensible motion, yet every body has at all times as much force acting upon it, as is equal to the most violent motion, it can be put into, without having its cohesion dissolved. Any body, whirled round its own *axis*, with a degree of velocity stronger than the power of its cohesion, flies asunder: a folding knife, moved round its *axis*, with a velocity superior

perior to the force of the back-spring, will fly open ; a drop of water, whenever it acquires a velocity in falling, greater than the degree of the cohesion of its particles, breaks into peices ; and a cannon ball, moved with sufficient quickness, would do the same. Hence we infer, that

XX. All motion in comparatively passive bodies (such I call terrestrial substances) tends toward the disunion of their cohesion ; and the force, which continues their motion, is a constant *nifus* to preserve their adhesion. The latter part of this proposition is no contradiction to the former ; and the whole is a necessary consequence of the preceding. A body moved out of its place would lose its cohesion, if it were not instantaneously pursued by the power which supports its cohesion ; and that power, acting upon it in the course of its motion, constantly pushes it forward, 'til its force is overcome by a contrary force acting in the form of resistance. Hence we conclude, that the power, which produces the motion, is the same with that which maintains the cohesion of bodies.

XXI. The weight of a body and its power are the same. A body moving upward or horizontally has no weight ; but in its motion it acts with a power or force exactly the same as its weight, added to the quantity of its motion ; and both these

are exactly proportioned to the force of its cohesion. A pound of lead in motion acts with a power as much superior to a pound of sponge, in the same degree of motion, as the size of the former is smaller than the size of the latter : for it is the same quantity of force or power, reduced to a smaller compass, which produces necessarily a greater effect in the place of its action. This is a certain proof, that cohesion, power, and motion are the same ; seeing they can be evidently analyzed into one another. It may be observed as a proof of the same, that two contiguous bodies have no power of action against one another, their force upon one another depends entirely upon the power of cohesion, acting in the form of sensible motion. We may further observe, that if there were not a constant effort of motion, acting upon every body, we could not put any body in motion. This if attended to needs little demonstration.

XXII. All bodies, comparatively passive, mechanically move towards that part, where the greatest effort of action is, if they are within that sphere of action : which obviously accounts for the power acting upon such bodies uniformly manifesting itself in the form of weight, called gravity. That sphere of action round any body, which gives it fixation, may properly be called its atmosphere. The extent of that sphere of action must be in proportion

portion to the quantity of matter in the body compressed, and the degrees of compactness its component parts can be reduced to by the active power. That active power mechanically must reduce all large bodies, such as this earth (which may be called the primary objects of its action) into an orbicular form ; because fixation cannot be accomplished unless the action be equal, or nearly so, on all sides of the body. Now as both the extent of a body's atmosphere, and the quantity of the power of that atmosphere, are in proportion to the body acted upon ; every detached part of that body placed any where within its atmosphere, must be pressed toward the place, where the action of the atmosphere is primarily directed, with a velocity proportioned to the power of the atmosphere in that primary direction.

XXIII. In all motion of detached bodies within the sphere of an atmosphere, there is a three-fold resistance constantly exerted, two of which are essential to all motion. The first, which is proper to smaller bodies moving within the atmosphere of larger ones, is the constant pressure upon them, towards that place where the greatest effort of motion is. Secondly the resistance they meet with from the fluid they move in. Thirdly, the reaction, which is constantly and mechanically

cally produced by the power, which forces all motion contrary to the two former resistances. For the quantity of force applied in all motion is double the quantity of motion produced by it. This is demonstrated by one moving elastic body striking directly against another of the same kind ; where we see the force, which moves the second with nearly the velocity of the first, exerts its resistance in the same proportion by stopping the motion of the first. So likewise two such elastic bodies, moving in a straight line with any given equal force against one another, upon percussion would be tossed back again with the same velocity in the opposite directions. In a *plenum*, the fluid parts, which support the fixation (according to §. XX.) and continue the motion of bodies, must rush in on all sides behind the body, and act in the form of a wedge. Hence

XXIV. As resistance is no principle of matter, it must be a principle inseparable from motion. And as nothing can produce resistance, save motions in contrary directions ; so all motion in the more passive parts of matter, must be excited and continued, by two contrary motions in the more subtil and mobile parts of matter, which are always the primary cause of motion.

XXV. These

XXV. These two primary and universal motions, which subsist by each other, cannot be weakened nor increased: so that, tho' to our view more bodies may be in motion, and with greater velocity, at one time than at another, yet the universal quantity of motion must always be the same.

XXVI The effects of primary motion upon the more passive parts of matter are uniform, unvariable, and unchangeable: so that these effects must overcome the greatest possible motion, art or accident can put bodies into. We can cause bodies to resist and move in a direction contrary to their weight, and nothing appears weaker than the resistance of the atmosphere to progression; yet any one of these is able in time to overcome the strongest impulses, which can be given bodies; yea it is able to break them in pieces, as we see by §. XIX.

Upon the whole, the strongest presumptions from analogy are in favour of the universal material mechanism of the operations of nature such as the obvious properties of matter itself, N. I. the power of impulse, its being the only sensible cause of motion, and the only intelligible one, if there subsists any other cause; the universal efficaciousness of motion, which would be lost in most moving bodies, if they were not every where
under

under the reciprocal conditions of cause and effect ; and the imaginary, occult, and uncertain nature of any other supposed cause ; for no *hypothesis* of occult causes of motion has ever been framed, which is not clogged with contradictions so obvious, as to be unworthy of the name of a philosophical principle.

Again, it appears by §. X. XI. XII. XIII. XIV. XV. That the very supposition of mechanical motion infers such conditions of matter, as can and shall, I hope, be proved to subsist by indisputable arguments, even such as can be examined : for all other supposed principles of motion are the subject of conjecture, which is incapable of proof ; and no reasoning upon them can in its nature amount to more than a certain degree of probability ; while every different *hypothesis* points out the uncertainty of others. This spreads a veil of doubt and incredibility over all the doctrines of the imagination, which are not supported by such sufficient evidence as our understandings are capable of, and of consequence demand. But if the above conditions of matter be the necessary consequence of motion by continued impulse ; then the proof of their existence is also the proof of that principle, which necessarily infers them.

The last evidence here asserted in favor of mechanism is, that all the *phenomena* in nature may be explained by it; and the three universal sensible properties of matter be resolved into the power of motion, acting upon and by material substances. When the powers and properties of sensible bodies can be analyzed into motion and its effects, and when these powers can only discover themselves by motion or a tendency to it; it must or ought to give satisfactory evidence, that motion is the direct cause of such effects and appearances. Every one must be sensible, what a loss it is to the increase of knowledge in the powers of nature, to have the finest and most curious productions of these powers reduced to unintelligible laws, and characterized by words for names which have no meaning, and which render the inventors of them no wiser, after all their pains, than the most heedless and unattentive.

It follows in order, that we should next proceed to examine the properties of celestial and terrestrial matter in their different classes, with their proper constitutions and constructure. These we must be acquainted with, previous to our understanding or being able to explain and account for the various productions and appearances which depend on them. These, thoroughly understood, will lead us into darkest recesses and laboratories of nature; but even a general knowledge of these principles, if it is
only

only just and founded upon certain principles, will make our further inquiries satisfactory, so far as they reach. The degrees of penetration into these principles and their effects must distinguish each person's reach as a natural philosopher, and not an acquaintance with a number of terms of art, depending upon memory and not capacity; and the knowlege of which flatters our vanity, without informing our judgement.

Upon an attentive survey of the operations of nature, every person will conclude (as is expressed by the motto of this *Number*) that if the existence of matter is wonderful, the beauty, variety, harmony and universally-mutual dependences of its operations, with their astonishing effects, is still more so.

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